

# DSN Research and Technology Support

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*The activities of the Development Support Group, at the Goldstone Deep Space Communications Complex, both at DSS 13 and the Microwave Test Facility (MTF) are discussed and progress given. Activities include interchange of the SDS-930 computers between DSS 13 and DSS 14 and subsequent installation and checkout; planetary radar support for the Mariner Venus/Mercury 1973 Mission and modifications to DSS 14 and DSS 13 necessary to continue such support; installation of a new Faraday rotation data collection system, relocation of pulsar capability from DSS 13 to DSS 14; dual-carrier activity on the 26-m-diameter antenna and a discussion of dual-carrier activity for the Goddard Space Flight Center carried out at MTF on components of the Spaceflight Tracking and Data Network waveguide system. Also reported is a novel way to effect replacement of the 400-kW klystron without removing the assembly from the Tricone Support Structure of the 64-m-diameter antenna.*

During the two months ending April 15, 1973, the Development Support Group was primarily engaged in the following activities.

## I. DSS 13 Activities

### A. In Support of Section 331

1. **Planetary radar data processing computer.** The planetary radar program is switching primarily to DSS 14 for monostatic operations. In order to accomplish this, a computer with a larger memory than the available SDS-930 was needed. The SDS-930 at DSS 13, which is equipped with 16,384 words of 24-bit memory, was inter-

changed with the SDS-930 at DSS 14, which has only 8192 words of memory. The installation at DSS 14 was under the direction of Xerox Data Systems, aided by personnel from DSS 13. The installation at DSS 13 was completely accomplished by DSS 13 personnel. Both machines are now fully operational with the machine at DSS 13 being equipped with three magnetic tape units, card reader, line printer, typewriter, and paper tape equipment.

2. **Planetary radar.** Continuing support of the Mariner Venus/Mercury 1973 (MVM73) Missions, three Venus ranging missions were performed subsequent to the installation of the larger memory SDS-930 into DSS 14.

Pseudonoise code generation and timing signals are now being generated at DSS 13 and transmitted to DSS 14 over the microwave link. Transmission, reception, modulation, control, and data processing now take place at DSS 14. Due to various equipment problems, both at DSS 13 and DSS 14, good measurements have not yet been consistently achieved although a total of 24 hours of measurements have been attempted.

As the R&D receiver at DSS 14 (used for these radar tracks) was originally configured, only the 30-MHz portion was gain-controlled. This was done with a motor-driven potentiometer remotely from the Venus station (DSS 13). At the time, this method was adequate and was used mainly for optimizing the signal-to-noise ratio in the microwave link between DSS 14 and DSS 13. Further signal-level control was accomplished in a portion of the DSS 13 receiver before feeding into the data processing equipment. With the recent move of this data processing equipment to DSS 14, this latter control had been lost. To temporarily compensate for this, we have installed locally selectable attenuation in the output of the DSS 14 R&D receiver. The attenuation range is 0–132 dB in 1-dB and 10-dB steps.

Also, the R&D receiver at DSS 14 has been modified to provide dual-bandwidth selection capability in the 30-MHz portion of the receiver. The operator can now select either a 2.5 or 0.455-MHz bandwidth remotely from the pedestal control room in the base of the 64-m antenna.

**3. Pulsar reception.** With the relocation of the SDS-930 computer to DSS 14, the routine reception of pulsars has also been transferred. However, prior to the removal of the equipment, various pulsars were successfully monitored for a total of 33 hours during this two-month period.

## **B. In Support of Section 333**

**1. Faraday rotation data collection.** The data from the dual-channel phase-lock receiver (Ref. 1) have, since original installation, been punched onto teletype paper tape and printed by the station data system. This tied up the data system 24 hours per day, 7 days per week. At our request, Section 333 has fabricated and delivered a “stand alone” data collection system which will not only put the dual-channel phase-lock receiver data onto punched paper tape, but will also similarly punch the data from the Stanford receiver which previously was only outputting onto an analog chart recorder. This equipment has been installed, checked, and is now functional.

**2. Sky survey.** Using the Noise-Adding Radiometer (NAR) and associated computing counter with program-

mer and programmed controller, and outputting onto analog chart recorder and digital printer, the 26-m antenna is used to perform sky survey work. This survey is made on weekends when the station is not manned, by placing the 26-m antenna into the desired fixed position and starting the data collection system. When the station is opened the following week, the data are removed and sent to Section 333 for analysis. During this two-month period a total of 56 hours of data were collected as the rotation of the Earth swept the antenna beam through the sky, recording radio sources, along with their angular diameter and noise temperature.

## **C. In Support of Section 335**

**1. Dual-uplink carrier testing.** With all waveguide and components carefully cleaned and reassembled, testing was resumed (Ref. 1). A quiet condition (intermodulation products essentially nondetectable, weaker than  $-180$  dBm) was established when transmitting dual 10-kW carriers out of the feedhorn with a reflector plate installed on the feedhorn. This plate reflects the energy out the side of the dish so that radiated energy intercepts neither the subreflector, quadripod, nor main reflector. To maintain this quiet condition, it is necessary to have the system very clean, all flanges carefully lapped, no scratches, nicks or grooves on the flanges, and no “curls” inside the waveguide. During these two months, 333 hours have been utilized in these tests.

For the past several months the R&D receiver at the Venus station (DSS 13) has been used in dual-carrier testing. In such usage, the receiver first local oscillator is fixed tuned to the desired receive frequency. This produces an open-loop signal which is used for computer spectrum analysis. After appropriate frequency conversion, the same signal is fed to a 455-kHz phase-locked loop which is used for detection and signal strength measurement of the intermodulation products produced by the transmitter. The dual-carrier testing procedure makes it desirable to leave the phase-lock loop tracking filter shorting switch in the unshorted position as much as possible. This provides unassisted lockup of the loop whenever a signal appears in the receiver passband. However, this mode of operation produces some operational difficulties in that very often there are large noise bursts accompanying the intermodulation products of interest. These noise bursts tend to drive the loop VCO frequency out of the loop pull-in range. In the past it had been necessary for the receiver operator to constantly monitor the VCO frequency and momentarily short the loop tracking filter whenever needed.

To alleviate this problem and free the operator for other work, the receiver has been modified slightly. A computing counter is programmed to monitor the VCO frequency and short the loop filter whenever the VCO frequency exceeds selectable limits. At present these limits are set at plus or minus 15 Hz from the nominal 455 kHz. The only hardware changes required were the construction of a buffer amplifier to isolate the computing counter and some simple wiring changes within the receiver. This modification has been installed and used with good results.

Other work in the receiver area included construction of dual-active lowpass filters needed for computer spectrum analysis in the dual-carrier experiment. These units, with their associated gain, replaced a commercially made amplifier and a two-channel bandpass filter. The units were tailored for the use and provide 40 dB of gain, a 3-dB bandwidth of 25 Hz, and a rolloff slope of 23 dB per octave.

Also in the receiver area, work is under way to replace the dc amplifier in the receiver AGC system with a newer model. This is necessary because units are no longer available and past failures have consumed the spares. The manufacturer's specifications for the new unit indicate that some performance improvement can be expected. A prototype module has been constructed and is being tested.

The maser/refrigerator previously installed (Ref. 1) developed a gain instability which necessitated its replacement. No DSN standard maser/refrigerators were available so a development maser/refrigerator with a superconducting magnet was installed. This solved the instability problem and system operation has been normal since that time.

**2. 400-kW transmitter testing.** In support of development of DSN-destined components of the high-power transmitter system, commercial power supplies were evaluated at DSS 13 for possible utilization as magnet and motor/generator field supplies at DSS 14. A new arc detector was also tested, using the 100-kW transmitter which is used for dual-carrier testing.

The high voltage (HV) for the high-power transmitter is regulated with the desired voltage being set into the control circuit by monitoring on an analog meter and adjusting a potentiometer. A new HV control chassis, with digital setting capability, has been developed. The desired value of HV is set into front panel digital switches and

the control unit maintains the preset value. This new unit was also tested at DSS 13.

**3. Dual-carrier testing.** Goddard Space Flight Center (GSFC) personnel have utilized the facilities of the Microwave Test Facility (MTF) to investigate the suitability of various waveguide components from the Spaceflight Tracking and Data Network (STDN) for dual-carrier operation. The latest testing, for a period of 18 days, was to determine if a precision-manufactured waveguide component was superior to a normal tolerance component. This test is discussed in some detail under the activities of the MTF elsewhere in this report.

#### **D. In Support of Section 422**

**DSS 14 DSN 400-kW transmitter repair.** Subsequent to the launch of the Pioneer 11 spacecraft on Thursday, April 5, the DSS 14 DSN 400-kW transmitter failed. The symptoms indicated either a defective klystron or a defective klystron mounting socket tank. With the Pioneer 11 "midcourse" maneuver scheduled for the following Tuesday, restoration to service was important. Personnel from DSS 13 were asked by the Section 335 Cognizant Development Engineer (CDE) to provide aid in service restoration.

Removal of the klystron from its socket tank is normally done on the ground since there is not sufficient height clearance in the Tricone Support Structure (TCSS) to permit hoisting clear of the socket tank and associated focusing magnet. However, getting the klystron and socket tank down to the ground takes several hours and time was important. By hoisting the focusing magnet and klystron as an assembly, the necessary height clearance was reduced so it became possible to effect removal and installation of the klystron into a new socket tank without removing the assembly from the TCSS. This removal, testing, installation into a new socket tank, reinstallation into the transmitter cabinet, and alignment of the output coupler to the klystron waveguide window was accomplished in 5½ hours by personnel, both JPL and Philco Ford Corporation, from DSS 13.

#### **E. In Support of Section 825**

**Science support.** To facilitate interpretation of the radiation measurements to be reported by Pioneer 10 at Jupiter encounter, Earth-based, long-term measurements of the radiation from Jupiter are desirable. These measurements are being taken using the DSS 13 26-m antenna and Noise-Adding Radiometer (NAR). Although the primary target is Jupiter, certain radio source calibrators

are also observed, such as 3C48, 3C123, and 3C353. These observations have utilized 51 hours during the past two months.

## II. Microwave Test Facility Activities

### In Support of Section 335

**1. Dual-carrier testing.** During February 1973 the Microwave Test Facility (MTF) performed testing, under dual-carrier conditions, of microwave components used in the antenna feed systems for the Manned Space Flight Network (MSFN).

The purpose of these tests was to determine if a precision-made orthomode junction assembly exhibited lower intermodulation product (IMP) levels than a similar component manufactured to standard commercial tolerances. Both MTF 20-kW S-band transmitters were utilized for this test. The equipment was configured as shown in Fig. 1. The diplexer, water load, and parametric amplifier used in this test were furnished by GSFC personnel.

The test configuration was operated without the component under test to assure that the basic test configuration was not generating intermodulation products. For ease of observation, the GSFC personnel chose to monitor the IMPs near the carriers as well as those in the receive

passband. GSFC personnel felt that the monitoring of low-order IMPs would give a more sensitive test for nonlinear activity in the components under test. The component under test was a quad orthomode junction which had been manufactured to close tolerances and assembled by dip-brazing. For control, a standard quad orthomode junction, which had been manufactured to standard tolerances and dip-brazed, was used. Microscopic inspection of the precision component revealed a number of hairline cracks in the brazed joints which were also evident in the control component.

The components were carefully installed alternately in the test setup to assure that the flanges, water load, diplexer, and other system components were not generating intermodulation products. Comparison between the test and control component showed no significant difference in intermodulation product performance under dual-carrier conditions. Both parts generated intermodulation products 50 dB or more stronger than were detectable without the test components installed.

**2. Conclusions.** The sharp edges and hairline cracks that are characteristic of dip-brazed components are sources of intermodulation products when operating under dual-carrier conditions. Tighter tolerance manufacturing did not give any detectable improvement in performance.

## Reference

1. Jackson, E. B., "DSN Research and Technology Support," in *The Deep Space Network Progress Report*, Technical Report 32-1526, Vol. XIV, pp. 91-93. Jet Propulsion Laboratory, Pasadena, Calif., Apr. 15, 1973.

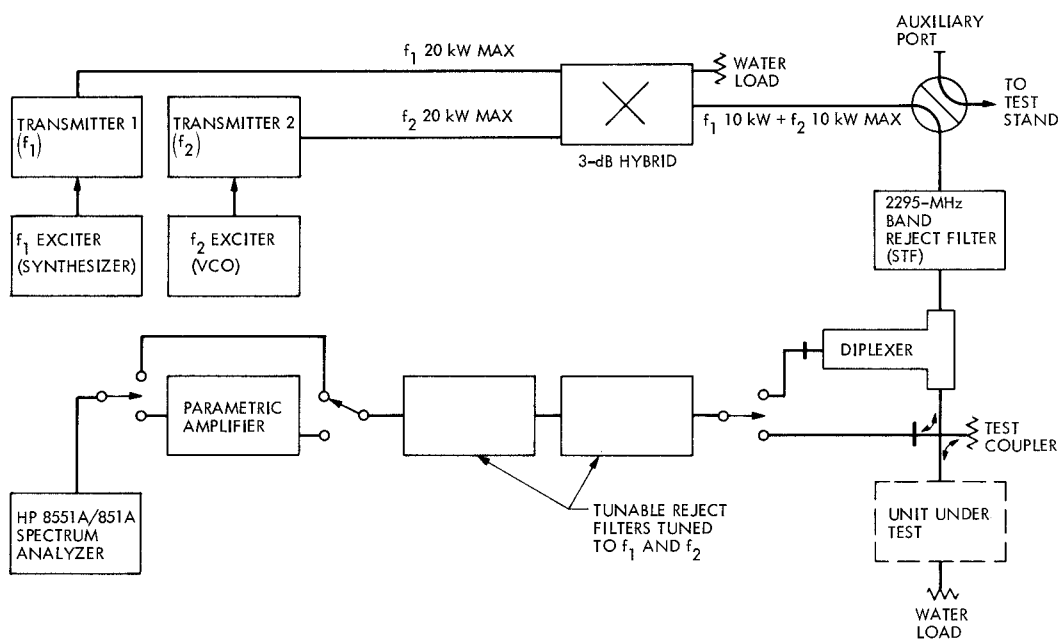


Fig. 1. Equipment configuration for GSFC dual-carrier tests